

able to operate the system properly with less than five minutes of coaching. The control process is shown in Fig. 2. As the system cycles through each display, the user waits until the top bar on the desired display lights and then utters a long syllable. The operator should be quiet while the lower bar is briefly lit. The upper bar then lights again briefly, at which time the operator must quickly utter a short syllable. The operator remains

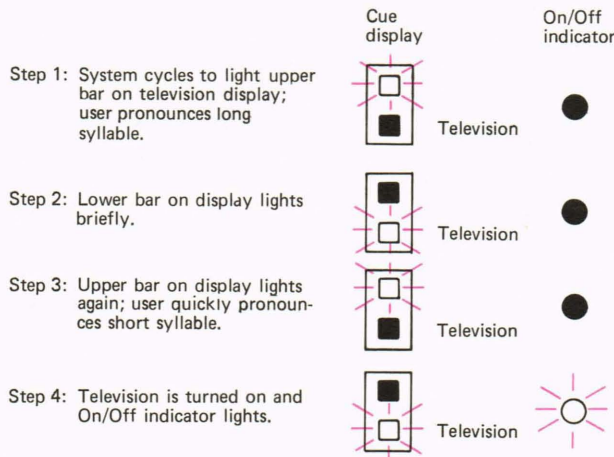


Fig. 2—Four-step process for user activation of a selected function (in this example, the television).

silent for 2.5 seconds, after which a series of beeps sound to indicate correct operation. The system will then resume cycling through all functions. When an attempt to activate an appliance is detected but does not fully meet the requirements, the display pauses at the attempted function. This permits another try at activation of a particular appliance without waiting a full cycle before the position is reached again.

Each appliance being controlled goes through continuing on/off cycles; i.e., if it is on, it will be turned off, and if it is off, it will be turned on.

For operator convenience, a test position for practice is included on the demonstration model with a separate display to indicate sound detection.

False activations with the demonstration model typically occur no more than once a day. It is hoped that a future model will have a standby mode, so as to further reduce the frequency of false activations. When the system is on standby, a normal activation utterance will be used to bring it into full operation. The system will return to standby after five minutes of no use. With this scheme, two false inputs within five minutes would be needed to cause an activation, thus making false activation highly unlikely.

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SUCCESSFUL LAUNCH OF MAGSAT

The National Aeronautics and Space Administration (NASA) Resource Observation Program has as one of its goals the use of space technology to advance our understanding of the processes that formed the present geologic features of the earth and how these dynamic processes relate to the emplacement of resources and to natural hazards.

One technique for achieving this goal is to measure the near-earth geomagnetic field. Before 1958, magnetic data from geographic regions were acquired over periods of years by means of numerous measurement techniques. But for many regions, particularly the oceans and the poles, data were either sparse or nonexistent.

Although measurements of the geomagnetic field from satellites began with the launch of Sputnik 3 in 1958, they have only been performed sporadically since, and only the NASA Polar Orbiting Geophysical Observatories (POGO's) have provided a truly accurate global geomagnetic survey. POGO's -2, -4, -6, operating between October 1965 and June 1971, obtained global measurements of the magnetic field magnitude approximately every 0.5 s over an altitude range of 400 to 1500 km, using

alkali-vapor magnetometers. These measurements were intended to map the main geopotential field originating in the earth's core, to determine the long-term time-related or local variations in that field, and to investigate short-term field perturbations caused by ionospheric currents. Several geomagnetic-field models and crustal anomaly maps based on the POGO data have been published. Their analysis has disclosed that, at lower altitudes, measurable field differences exist because of anomalies in the earth's crust, thus pointing the way to a new class of investigations.

Accordingly, NASA, with close United States Geological Survey (USGS) involvement, has undertaken to obtain measurements for the USGS to use in deriving magnetic-field maps that will be accurate for the 1980 epoch. Directional measurements will resolve ambiguities in field modeling and magnetic anomaly mapping. Increased resolution and higher signal levels from anomalous fields will help overcome shortcomings of the POGO data for making anomaly maps.

APL was selected to design, build, and test the satellite, known as MAGSAT, based on spare com-

ponents and designs available from the Small Astronomy Satellite (SAS) programs. The spacecraft carries a total field (scalar) magnetometer and a directional (vector) magnetometer supplied by NASA as government-furnished equipment. The scalar magnetometer is making absolute measurements of the ambient magnetic field to an accuracy of 3γ . The directional measurements of the vector magnetometer are made with an overall accuracy of the magnetic vector of 6γ .

The spacecraft comprises two major assemblies: (a) a base module of the SAS-C design incorporating the power system, telemetry, and command systems and the attitude control system, and (b) an instrument module designed specifically to meet the requirements of the mission. An optical bench supports two star cameras for determining attitude. The magnetometers are mounted on a precision platform that in turn is extended 6 m from the spacecraft to reduce the effect of satellite magnetic fields on the sensors. An optical device is installed on the optical bench with mirrors on the remote instrument platform to provide a measure of the relative angular displacements between the two. Known as the Attitude Transfer System, the device will permit scientists to use the star camera data to locate the orientation in space of the magnetometers corresponding to each set of measurements.

Launch occurred at 9:16 am EST on October 30, 1979, from Vandenberg AFB, Calif. The NASA/DoD Scout launch vehicle placed MAGSAT in a near-optimal orbit with a perigee of 352 km and an apogee of 578 km inclined at 97° . The period is 93 min. A complex sequence of preprogrammed maneuvers (stored commands) was then successfully carried out to orient the satellite properly with the sun to ensure enough solar array output to charge the battery. By the following day, attitude control (earth lock) was achieved, and on November 1, 1979, the magnetometer boom was deployed successfully. All spacecraft and instrument module subsystems are performing as intended, and the magnetometers are returning good data. After less than one week, the satellite was in the routine data-gathering mode.

Because of the satellite's low altitude, its lifetime will be determined by aerodynamic drag. Current predictions of the atmospheric density, as influenced by solar activity, lead to an estimated satellite lifetime of 130 to 200 days. If, as expected, MAGSAT continues to operate properly throughout this lifetime, all mission objectives should be achieved.

The MAGSAT mission objectives, which were established jointly by NASA and the USGS, are to

1. Obtain an accurate, up-to-date quantitative description of the earth's main magnetic field. Accuracy goals are 6γ rss in each component at the satellite altitude, which results in 20γ rss in

Table 1
FIELDS OF INVESTIGATION AND PRINCIPAL INVESTIGATORS

<i>Field of Investigation</i>	<i>Investigator</i>	<i>Affiliation</i>	
<i>Geology</i>	R. S. Carmichael	University of Iowa	
	R. Godivier	ORSTOM, Paris	
	S. E. Haggerty	University of Massachusetts	
	D. H. Hall	University of Manitoba	
	D. A. Hastings	Michigan Technological University	
	I. G. Pacca	Universidade de Sao Paulo	
	D. W. Strangway	University of Toronto	
	I. J. Won	North Carolina State University	
	<i>Geophysics</i>	C. R. Bentley	University of Wisconsin
		B. N. Bhargava	Indian Institute of Geomagnetism
R. L. Coles		Geomagnetic Service of Canada	
J. C. Dooley		Bureau of Mineral Resources, Canberra	
N. Fukushima		University of Tokyo	
P. Gasparini		University of Naples	
W. S. Hinze		Purdue University	
B. D. Johnson		Macquarie University	
G. R. Keller		University of Texas	
J. L. leMouel		Institut de Physique du Globe, Toulouse	
<i>Field modeling</i>	M. A. Mayhew	Business and Technological Systems	
	D. A. Barraclough	Institute of Geological Sciences, Edinburgh	
	B. P. Gibbs	Business and Technological Systems	
	M. A. Mayhew	Business and Technological Systems	
	P. P. Stern	NASA/GSFC	
<i>Marine studies</i>	R. F. Brammer	Analytic Sciences Corp.	
	C. G. A. Harrison	University of Miami	
	J. L. LaBrecque	Lamont-Doherty Geological Observatory	
<i>Core/mantle studies</i>	E. R. Benton	University of Colorado	
	J. F. Hermance	Brown University	
<i>Magneto-sphere/ionosphere interactions</i>	J. R. Burrows	National Research Council of Canada	
	P. M. Klumpar	University of Texas	
	T. A. Potemra	JHU/APL	
	R. D. Regan	Phoenix Corp.	

each component at the earth's surface in its representation of the field from the earth's core at the time of the measurement;

2. Provide data and a worldwide magnetic-field model suitable for the USGS to use in updating and refining both world and regional magnetic charts;

3. Compile a global scalar and vector crustal magnetic anomaly map. Accuracy goals are 3γ rrs in magnitude and 6γ rrs in each component for the scalar and the vector magnetometers, respectively. The spatial resolution goal of the anomaly map is 300 km; and
4. Interpret the crustal anomaly map, in conjunction with correlative data, in terms of geologic/geophysical models of the earth's crust for assessing natural resources and determining future exploration strategy.

The objectives will be achieved by investigations that will be carried out at the Goddard Space Flight Center and at the USGS by distinguished members of the scientific community. Fields being investigated include geology, geophysics, field modeling, marine and core/mantle studies, and magnetosphere/ionosphere interactions. APL will be involved in the last investigation (Table 1).

LEWIS D. ECKARD
Space Department

ENCOUNTERS WITH JUPITER: THE LOW ENERGY CHARGED PARTICLE RESULTS OF VOYAGER

Like the Earth, Jupiter has a magnetic and charged particle environment—a magnetosphere—that presents an obstacle to solar wind plasma flowing outward from the sun. Using a gas dynamics analogy, one envisions a viscous interaction in which solar wind flow molds the magnetosphere into a comet-like shape. The magnetosphere itself is subject to internal forces that may alter this picture somewhat, although the basic idea of an “obstacle to a flow” is a useful analogy. Filled with intense fluxes of high energy particles, the Jovian magnetosphere extends over 10 million km away from the planet and thus represents an object of truly astrophysical scale.

Launched in the summer of 1977, the twin Voyager spacecraft flew past Jupiter in March and July, 1979. The Voyager trajectories enabled the spacecraft to encounter the Galilean satellites (the four largest moons of Jupiter) and to make *in situ* measurements of the Jovian magnetosphere. As seen in Fig. 1, both spacecraft approached the planet in before-noon local time meridians. Voyager 1 left Jupiter in the meridian near 5 a.m. and Voyager 2 left further downstream in the meridian at about 3 a.m. In effect, the outbound Voyagers sampled different regions of the Jovian magnetosphere. Both spacecraft remained close to the ecliptic plane at low Jovigraphic latitudes.

Each voyager probe carried 11 scientific experiments designed to investigate Jupiter, its major satellites, its particle and field environment, and the interaction of that environment with the solar wind. Included was the Low Energy Charged Particle (LECP) experiment. Designed and built by the Applied Physics Laboratory in collaboration with several other institutions, the LECP instrumenta-

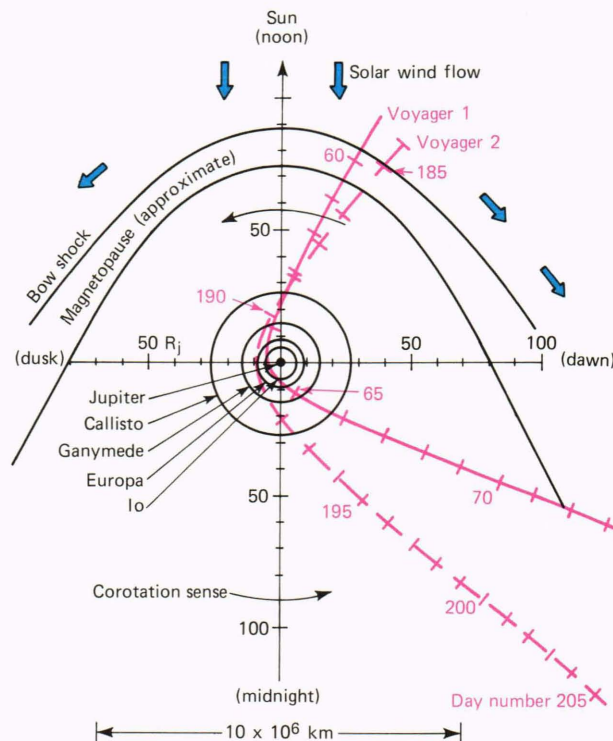


Fig. 1—Polar plot of Voyager 1 and 2 trajectories for the Jupiter encounters. The “magnetopause” curve represents the approximate boundary of the Jovian magnetosphere while the “bow shock” curve represents the detached shock generated by supersonic solar wind flow past the magnetosphere (blue arrows). The orbits of the four Galilean satellites are indicated.

tion can measure ions of energies of 28 keV or greater and electrons of energies of 15 keV or greater.¹ The LECP can also provide compositional information about the particle environment it samples. The LECP detector array is mounted on a scan platform that rotates the instrument in eight discrete 45° steps so as to provide 360° coverage. The instrument has an effective dynamic range of

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